Remote Sensing Techniques To Assess Active Fire and Post Fire Effects: Clarification of Terminology

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RSAC 11th Biennial Conference, 27th April 2006

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Further Thanks to M.Wooster, C.Hardy, A.Hudak, and P.Morgan for slides & images

Funding from:

Joint Fire Sciences Program – 05-4-1-07

NASA via the Forest Public Access Resource Center (ForestPARC)
Outline

• Review of Terminology
• Highlight Recent Remote Sensing Research in:
  ➢ Active Fire Characteristics
  ➢ Post-Fire Effects
• Conclusions

Following the 2\textsuperscript{nd} Session:
• Panel Discussion
• Handout
Fire Intensity, Fire Severity, and Burn Severity…

**Fire Intensity** is a description of fire behavior quantified by the temperature of, and energy released by, the fire.

**Fire Severity** integrates active fire characteristics and immediate post-fire effects on the local environment.

**Burn Severity** incorporates both short and long-term post-fire effects on the local and regional environment. Burn severity is defined by the degree to which an ecosystem has changed due to the fire.

How do these terms relate on a temporal scale?

These terms can be thought to exist on a temporal continuum:


Source of Confusion: The Terms Fire Severity and Burn Severity are used inconsistently in the Remote Sensing literature.
Severity?

- Magnitude of Ecological Change
- Value Laden Term
- Negative Connotations
- Public & Policy Miscommunication

Ground Measures of Severity Inferred from Remote Sensing:

- Fire duration and heat transfer
- Vegetation consumption
- White ash production
- Change in surface reflectance
- Alteration in soil properties
- Changes in the litter and duff layers
- Long-term vegetation mortality and recovery

Challenges/Problems

(A) Several Measures = Biomass Combusted

(B) High Spatial Variability of Post-Fire Condition

High spatial variability of White Ash, Deep Char, etc

Lightly burned areas exhibit large reflectance ranges

(C) Reported Non-linear Response Between CBI and NBR – A CBI ceiling?


High Fire Severity and Low Burn Severity
High Fire Severity and Low Burn Severity
Simplifying the Fire Disturbance Continuum:

- Limit use of the Terms Fire Severity & Burn Severity
- Use Terms Active-Fire Characteristics and Post-Fire Effects
- Describe and Quantify the Actual Processes Being Assessed
- Make sure that satellites CAN also measure these processes!
Active Fire Characteristics
Measuring Fire Temp & Energy Radiated by Fires

The Kaufman TIR Method:

\[ R_{\text{fre}} = 4.34 \times 10^{-19} (T_4^8 - T_{4b}^8) \]

\( T = \) TIR radiance, \( b = \) background


The Wooster MIR Method:

\[ \text{FRP} = \text{Pixel Area} \times \left[ 1.89 \left( L_{\text{MIR},f} - L_{\text{MIR},b} \right) \right] \times 10^{-3} \]


Notable Others:

Riggan et al 2000, 2004; Butler et al 2004; Denission et al 2006a,b
From Radiative Power to Fuel Combusted:


Testing:
Real MODIS and BIRD FRP data in Boreal Forest

Southern Africa FRP, 3-8 September 2003

Biomass Combusted = 3.2 million tonnes (1.5 Mtonnes C)

Fire Radiative Power differs between surface and crown fires and between heading and backing fires.

Fire type → improve fire emission and combustion models
→ relate to vegetation mortality and recovery

Fires in Northern Idaho and Western Montana: 1875-1990

Post-fire Effects
What the Sensors See:

General **DECREASE** in VIS-NIR $[0.4 \text{ to } 1.6 \ \mu m]$ surface reflectance due to char deposition and removal of vegetation:

At localized points **VIS-NIR surface reflectance** can **INCREASE** due to soil char or combustion of CWD:

**INCREASE** in SWIR reflectance $[1.6 \text{ to } 2.5 \ \mu m]$ and brightness temperatures $[\text{i.e. } 3.6 \ \mu m]$ due to increased soil & char cover and reduction in evapotranspiration

Common Spectral Indices

Normalized Difference Vegetation Index (NDVI), Normalized Burn Ratio (NBR), and delta Normalized Burn Ratio (dNBR)

\[
\text{NDVI} = \frac{\text{NIR} - \text{RED}}{\text{NIR} + \text{RED}}
\]

\[
\text{NBR} = \frac{\text{NIR} - \text{SWIR}}{\text{NIR} + \text{SWIR}}
\]

\[
\text{dNBR} = \text{NBR}_{\text{prefire}} - \text{NBR}_{\text{postfire}}
\]


Newer Indices Use all 3 Effects:

\[ NBRT_1 = \frac{\text{NIR} - (\text{SWIR} \times S_{\text{TIR}})}{\text{NIR} + (\text{SWIR} \times S_{\text{TIR}})} \]

\[ \text{SAVIT} = \frac{(\text{NIR} - (\text{Red} \times S_{\text{TIR}})) \times (1 + \text{L})}{(\text{NIR} + (\text{SWIR} \times S_{\text{TIR}}) + \text{L})} \]

Similar to Composite Approaches:


Smith et al 2005, in review; Holden et al 2005, in prep;
Using Remote Sensing to Evaluate Post-Fire Effects other than the Area Burned

The Remote Sensing and Field Measures Should Physically Relate:

Need to use Quantitative measures beyond the ‘Qualitative’ CBI

Source: Hudak, Morgan, Hardy et al
Use of Veg, Char, and Soil Fractions

- Improved indicators that are mappable and inherently scalable
- Landsat char fraction map of burned area accurate to 98% when compared to coincident IKONOS imagery

Source: Hudak, Morgan, Hardy et al

(Smith et al in review)
Conclusions:

• Recent advances in the remote sensing of fires

• Current confusion in use of fire intensity and severity related terms

• Need to ensure that we quantify ground processes that the satellite can ‘see’

• Thermal IR methods have great promise for characterizing post-fire effects.